

Phytophthora ramorum

Status (include where present, recent European outbreaks (if applicable) and key known research activities).

- *Phytophthora* are oomycetes that are typically root and root collar pathogens adapted to damp conditions. ***Phytophthora ramorum* (PR)** is renowned world-wide as one of the most important. In addition to motile zoospores, which permit spread in water, sporangia (spore sacs in which zoospores are formed— see fig below) can be shed from infected leaves allowing airborne spread. There are a wide range of potential hosts (including coniferous and broadleaved trees and woody ornamentals (notably Rhododendron).
- PR was first detected in Europe in 1993 (nurseries) and identified as the causal agent for widespread oak death in California in 2000. It was first detected in the UK in 2002 in nurseries, and then in the wider environment (particularly managed gardens of ornamentals incl. rhododendrons esp. in SW England with a few broadleaved trees affected) in 2003. This triggered large-scale rhododendron removal. Large-scale dieback and mortality on Japanese larch was found in 2009 in SW England and this subsequently became widespread throughout western Wales, Scotland and Northern Ireland. There have been recent outbreaks in larch in northern France, and outbreaks in western Britain (including Scotland) have continued to spread, with occasional findings further to the east.
- Four lineages are presumed to relate to four introductions by pathways unknown from an origin now suspected to be SE Asia to North America (NA1 and NA2) and Europe (EU 1 and EU2). Both lineages found in Europe are also found in Scotland. It seems likely that EU2 is a more recent introduction than EU1 and moved from N Ireland to SW Scotland. EU2 appears a more effective colonizer of larch bark than EU1, although slightly poorer at sporulating. Genetic diversity within lineages is being uncovered and revealing clusters that suggest differences in sporulating and infection behaviour.
- Current research includes distribution/range changes in lineages; screening for potential resistance in Japanese larch; susceptibility of Sitka spruce (and other main conifer species) to main lineages, and spore numbers likely to cause infection; risks associated with different modes of inoculum transfer, and implications for dispersal distances; and development of low-cost trapping methods to facilitate above studies.



Left: *P. ramorum* spore sac with zoospores; Right: Scottish larch forest showing diseased trees (credit Forest Research)

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Scottish-specific issues (include industries at risk; likelihood of arrival; possible scale of economic/environmental/social impact of arrival)

- PR has had a substantial impact on forest landscapes in SW Scotland and led to major changes in policy and practice. Movement restrictions, statutory plant health notices and implementation of a core 'Management Zone' were adopted. This impacted timing and extent of felling of larch and in turn market development, infrastructure requirements and deployment of labour.
- Monitoring of larch health in Scotland has been undertaken by aerial survey. Suspect sightings from the air are followed up by ground survey and collection of samples for laboratory diagnosis.
- Aerial dispersal is thought to be usually localized (hundreds of metres) but outliers at a few kms are possible. This has guided management to prioritise removal of inoculum from the leading edge of the outbreak backwards although it is now acknowledged that felling in the core zone should complement this spatial targeting.
- Management of the outbreak remains a priority for the Scottish Govt. The sector is particularly concerned at the N and E spread from the existing outbreak, the prospects of other conifer species (esp. Sitka spruce) being affected and the long-term prospects for larch elsewhere in Scotland (where initial climate modelling suggested low risk).
- Preliminary results from the 2019 aerial survey (presented to STHAG in June 2019), suggested the number of suspect cases found was considerably less than 2018. This may be due to weather variation, success of control (felling of the highest sporulators) or dynamics of the PR population.

Knowledge Gaps

- Effectiveness of overall control measures.
- Relative importance of spread mechanisms - e.g. wind or movement of contaminated material.
- Presence of sporulating hosts not detected/surveilled at present.

PHC Perspective

There is no doubt that the current PR outbreak is of major economic, social and environmental impact. The situation (together with knowledge/understanding of PR and factors shaping the outbreak) is fluid and emerging – a case of adaptive management to an outbreak that was at initiation of major surprise to the sector and to pathologists. The complexity is considerable, including climate/weather, host availability and lineage variabilities, meaning that success or otherwise of existing measures is hard to gauge and there have been calls for a thorough review.

Key Priorities and Recommendations (for policy, industry or scientific stakeholders)

- Emphasise importance of biosecurity to avoid introduction of yet more forms of *P ramorum* into Scotland to restrict opportunities for genetic combination and greater variation in behavior.
- Continue to investigate population dynamics and susceptibility of other conifers (and shrub species in the natural environment).
- Consider a review of outbreak management drawing on international experiences.

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